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Parallel transport gates in a mixed-species ion trap processor[1]

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Scaled up quantum information processors will require large numbers of parallel gate operations. For ion trap quantum processing, a promising approach is to perform these operations in separated regions of a multi-zone processing chip between which quantum information is transported either by distributed photonic entanglement or by deterministic shuttling of the ions through the array. However scaling the technology for controlling pulsed laser beams which address each of multiple regions appears challenging. I will describe recent work on the control of both beryllium and calcium ions by transporting ions through static laser beams [2], [3]. We have demonstrated both parallel individually addressed operations as well as sequences of operations. Work is in progress towards multi-qubit gates, which requires good control of the ion transport velocity. We have developed a number of techniques for measuring and optimizing velocities in our trap, enabling significant improvements in performance [4]. In addition to direct results, I will give an overview of our multi-species apparatus, including recent results on high fidelity multi-qubit gates.

[1]We are grateful for funding from the Swiss National Science Foundation and the ETH Zurich.

[2]Leibfried et al. PRA 76:032324 (2007)
[3]deClercq et al. arXiv:1509.06624 (2015)
[4]deClercq et al. arXiv:1509.07083 (2015)